Osborne Reynolds' Submechanics of the Universe: A Bridge between Classical and Modern Physics

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> "By this research it is shown that there is one, and only one, conceivable purely mechanical system capable of accounting for all the physical evidence, as we know it in the Universe. The system is neither more nor less than an arrangement, of indefinite extent, of uniform spherical grains generally in normal piling so close that the grains cannot change their neighbors, although continually in relative motion with each other; the grains being of changeless shape and size; thus constituting, to a first approximation, an elastic medium with six axes of elasticity symmetrically placed.", Osborne Reynolds (1, p. 1).

Thus begins one of the most revolutionary achievements in the history of science. Osborne Reynolds, F.R.S. (1842-1912), a British engineer and educator, earned the respect of his peers and the devotion of his students. Today he is recognized mainly for his contributions to the study of fluid dynamics, turbulence, and tribology (2,3); but Reynolds perceived these as only preliminaries to his grand synthesis - an axiomatic theory of a particulate aether. The prevailing view today is that Reynolds' quasicrystalline medium is an antiquated curiosity, an interesting exercise which was overtaken by events of the time.

My position is that Reynolds' "Sub-Mechanics of the Universe" (henceforth, SMU) is a bridge between classical and modern physics; that it is consistent with relativity and quantum theory; and that it provides a solid foundation for the Theory Of Everything. I believe that if scientists can shift their paradigms to incorporate Reynolds' SMU model, a new age of enlightenment in physics will be upon us. I will elaborate upon my reasons, but first let me give you some of my background.

In 1968, while employed as a research engineer at the Franklin Institute Research Laboratories in Philadelphia, Pennsylvania, USA, I invented a device which consisted of a dilatant fluid enclosed and sealed in a rubber sack. At the time I had no idea what dilatancy was, so I asked some of my associates in the physics department, got the basic vocabulary and set off to the Franklin Institute Library to do some research. This was the beginning of my education in rheology and the work of Osborne Reynolds. Also, in 1968, totally unknown to me, the Osborne Reynolds Centennial Celebration was being conducted at the University of Manchester.

Whilst researching the prior art in dilatancy, I was surprised and intrigued to find, in a book on rheology (4, p. 4), that Osborne Reynolds' had based an entire theory of the universe on a dilatant medium. I continued to pursue my applications and subsequently received a patent on a toy (5) and later, through the US Navy, I was granted a patent on an impact absorber based on the same principle (6). The rheologically dilatant suspension used in my patents has a critical shear rate which can be kinaesthetically perceived on handling it. Below a critical shear rate it behaves as a liquid, above this rate it behaves as a solid. There seemed to be some analogy between this critical flow rate and relativistic phenomena at the speed of light.

As an amateur physicist, I was thus fascinated with Reynolds' SMU model and continued to study it and related topics over the past twenty years. Throughout my research on Reynolds, I could never understand the obscurity into which his Sub-Mechanics of the Universe sank. I expected it to be treated in Whittaker's momentous work, "A History of the Theories of Aether and Electricity" (7) and in Schaffner's book on nineteenth century aether theories (8). Neither gives it even a passing mention. I saw Whittaker's omission as particularly curious and, yes, grievous. I was later to find reasons for the neglect of Reynolds' SMU.

Aside from the reference by Blair (4), I have found only two popular references to Reynolds SMU: an article in Scientific American (9, pp. 99-100) which mentions the SMU and also references the work of W. W. Rouse Ball (10). Ball states (10, pp. 469-470):

> "It is alleged that the theory accounts for the known phenomena of gravity, electricity, and light provided the size of its grains are properly chosen. ... This theory is in itself more plausible than the electron hypothesis, but its consequences have not yet been fully worked out."

John Gardiner's Scientific American article (9) also refers to Reynolds' popular lecture entitled, "On an Inversion of Ideas as to the Structure of the Universe" (11). He states, "Reynolds' inverted idea is less crazy than it sounds." and then mentions the "new ether" theories of P. A. M. Dirac and John A. Wheeler.

As my research progressed, I uncovered a review of Reynolds' SMU by G. H. Bryan in Nature (12). Bryan writes:

> "... It may safely be described as one of the most remarkable attempts that have been made of recent years to formulate a dynamical system capable of accounting for all physical phenomena at present known. A theory such as here set forth may not improbably play the same part in modern science that was assumed by the atomic theory and the kinetic theory of gases in the science of the time when these theories were propounded. ..."

> "... The mathematical reasoning is very difficult, in some places almost impossible, to follow, owing to the large number of doubtful points or inaccuracies in the equations. Even if the fundamental conclusions should prove to be correct, there are many points in the argument which are at present obscure, and require to be cleared up. To take a few examples. ... In ordinary circumstances there is no useful purpose served in filling a review with a list of errata which any reader could easily correct for himself. But the present investigation would be difficult to follow even under the most favourable conditions, and the presence of so many formulae and statements which cannot possibly be correct as they stand renders the task well nigh hopeless. ..."

> "... An objection of an entirely different character applies to the sections in which Maxwell's law of distribution of velocity components and partition of energy is extended to a medium of closely packed spheres such as that considered by Prof. Reynolds. ... To assume the law to hold good in the extreme case of a medium, the ultimate particles of which are permanently interlocked, must be regarded, failing other evidence than that given by Maxwell, as a very doubtful step. ..."
>
> "It may be confidently anticipated that Prof. Osborne Reynolds's granular medium will play an important part in the physics of the future. It is, however, to be hoped that the subject will receive careful and critical study in the hands of numerous mathematical physicists, and that it will not be left for the experimenter and philosopher blindly to accept Prof. Reynolds's doctrines as the basis of speculations about things which they do not understand. The practice of assuming statements to be true because Maxwell made them has been too prevalent in the past, and there is not very much difference between those who adopt this attitude and writers who publish papers at their own expense to show that the earth is not round or that gravitation does not exist. The dogmatic attacks of the former class of philosopher often afford plenty of material for the abusive attacks of the latter."

This review correctly points out some of the problems with the SMU and can hardly be called an enthusiastic endorsement of it. Reasons for closeting the SMU skeleton were appearing. At the time Reynolds did his work, the electron was still just a hypothesis and the structure of the atom was unknown.

Reynolds' obituary (13) devotes only half a page out of six to his aether theory. The author (H. L.) states a view probably reflecting those of Reynolds' contemporaries,

> "... In spite of the interest of the experiments," (on volumetric dilatancy, B.R.) "Reynolds was careful to state that the theory was anterior to them. He had long speculated on the possibility of a mechanical theory of matter and ether which should, amongst other things, resolve the riddle of gravitation. He had convinced himself that a medium composed of smooth rigid grains (e.g. spheres) in contact was promising, and it was by reflection on the properties of such a medium that he was led to forsee the somewhat paradoxical behaviour of sand and other granular aggregations which was so beautifully confirmed by his experiments."
>
> "The results of the remarkable physical speculation referred to are recorded in the long memoir on the "Sub-Mechanics of the Universe" which marked the close of his scientific career. This was read before the Royal Society on February 3, 1902, and now constitutes the third and final volume of his collected papers. Unfortunately, illness had already begun gravely to impair his powers of expression, and the memoir as it stands is affected with omissions and discontinuities which render it unusually difficult to follow. No one who has

> studied the work of Reynolds can doubt that it embodies ideas of great value, as well as of striking originality; but it is to be feared that their significance will hardly be appreciated until some future investigator, treading a parallel path, recognizes them with the true sympathy of genius, and puts them in their proper light."

His obituary mentions his illness and the decline of his powers of expression. Subsequent information indicates that Reynolds became mentally ill; perhaps it was senile dementia or Alzheimer's disease. This illness may explain the obvious neglect of his greatest work by his contemporaries. Who would take seriously the product of a sick mind? This is especially so, in view of the fact that the work contained many errors and required such an inversion of preconceived ideas, such a shift of paradigm. Also, Reynolds' SMU was competing for attention with the many major discoveries which followed one upon the other shortly after turn of the century. Now, 85 years later, it appears that Reynolds might have a more sympathetic audience.

Let us now turn to Reynolds' SMU itself. I will first allow Reynolds' speak for himself. In explaining gravitation with the SMU model, Reynolds writes (1, p. 3):

> "Efforts, proportional to the inverse square of the distance, to cause two negative inequalities to approach are the result of those components of the dilatation (taken at first approximation only) which are caused by the variation of those components of the inward strain which cause curvature in the normal piling of the medium. The other components of the strain being parallel, distortions which satisfy the condition of geometrical similarity do not affect the effort. If the grains were indefinitely small, there would be no effort. Thus, the diameter of a grain is the parameter of the effort; and multiplying this diameter by the curvature of the medium (underlining by B.R.) and again by the mean pressure of the medium the product measures the intensity of the effort.
>
> The dilation diminishes as the centers of the negative inequalities approach, and work is done by the pressure in the medium, outside the singular surfaces, to bring the negative inequalities together.
>
> The efforts to cause the negative inequalities to approach correspond, exactly, to gravitation, if matter represents negative mass."

Reynolds then shows the calculation which results in the model's correct prediction of gravitational force at the surface of the earth, concluding:

> "The inversion is thus complete. Matter is an absence of mass, and the effort to bring the negative inequalities together is also an effort on the mass to recede. And since the actions are those of positive pressure there is no attraction involved; the efforts being the result of the virtual diminution of the pressure inwards."

Not being content to explain gravitation, Reynolds went on to electricity (1, p. 4):

> "Besides the positive and negative inequalities, there is another inequality which may be easily conceived, and - this is of fundamental importance - whatever may be the cause, it is possible to conceive that a number of grains may be removed from some position in the otherwise uniform medium, to another position. Thus instituting a complex inequality, as between two inequalities, one positive and the other negative; the number of grains in excess in the one being exactly the same as the number deficient in the other.
>
> The complex inequalities differ fundamentally from the gravitating inequalities inasmuch as the former involve an absolute displacement of mass while the latter have no effect on the mean position of the mass in the medium; and in respect of involving absolute displacement of mass the complex inequalities correspond with electricity."

Reynolds' then goes on to some speculations about electricity, which we now know to be incorrect. We know that an electron has mass and cannot be only a massless complex inequality; but a complex inequality which has a net deficiency of aether grains. He then computes the relative intensities of electric to gravitational forces for a complex inequality and arrives at a figure of gravity being eighty-one thousand billion times less than the electric force. If his billion is 10 exp (12), then this figure is, in scientific notation, 8.1 x 10 exp (16). This figure differs from what is computed today; but the fact that he was able to compute it from his model at the turn of the century is testimony of its power.

The problem with an aether based on the solid-elastic continuum model is that such a medium had to be stiff enough to transmit the extremely high frequency vibrations of light on the one hand, yet diaphanous enough to permit the unhindered movement of the heavenly bodies. According to Reynolds' his SMU model satisfies these paradoxical requirements (1, p. 250):

> "The difficulties in conceiving the free motion of the ether through matter do not present themselves in the analysis of the properties of the granular medium as now accomplished. This follows from the analysis which has been effected in this and the previous section."
>
> "... Whence it follows that the singular surfaces which correspond to matter are free to move in any direction through the medium without resistance, and vice versa the medium is free to move in any direction through the singular surfaces without resistance. And that the waves corresponding to those of light are instituted and absorbed by the singular surfaces only. So that after institution at the place where the singular surfaces are, the motion of the waves depends solely on the mean motion of the medium, and the rate of propagation is equal in all directions until they again come to singular surfaces. Thus all paradox is removed

> and the explanation of aberration is established on the basis of the absence of any appreciable resistance to the medium in passing through matter."
>
> Thus besides the explanations by definite analysis of: the potential energy,
> the propagation of transverse waves of light, the apparent absence of any rate of degradation of light, the lack of evidence of normal waves, the gravitation of matter, electricity,
> which explanations render the purely mechanical substructure of the universe indefinitely probable, we have by further analyses obtained ..."

With this, followed by a list of fourteen further proofs, Reynolds' finishes his dramatic contribution to science, a momentous life's work.

Reynolds read the SMU before the Royal Society on February 3, 1902. This was three years before publication of Albert Einstein's special theory of relativity and nine years before his general theory of relativity. As quoted above, Reynolds equated the gravitational field with an inwardly acting strain gradient surrounding material bodies and derived this from the curvature of the medium". This sounds very much like curvature of the space-time continuum; Einstein's geometricizing of space expressed via general tensor notation. Unfortunately Reynolds' used clumsy multiple integrals, not the streamlined tensor notation.

Einstein devoted the latter part of his career to the formulation of a theory which could subsume all physical phenomena under a single rubric. He failed. It hardly seems possible that Einstein was unaware of Reynolds' theory; but would he have failed if he had been aware of it?

In his popular lecture, "On an Inversion of Ideas as to the Structure of the Universe, Reynolds makes his ideas more accessible (11, pp. 21-22):

> "It may help in the formation of a conception if we recall Lord Kelvin's theory of vortex atoms which promised so much, and afforded the first conception of matter passing through a space completely occupied by matter without resistance. In that theory the vortex ring, in which the displacement is from the inside, was the instrument, so to speak, that was to secure the free motion of matter through the medium. This theory has been found intractable, and is now shown to be impossible. But in its place we have the external propagation, which presents none of the difficulties of its predecessor.
>
> Nor can we pass this stage without calling attention to the startling conclusion to which this external propagation leads.
>
> 8. Singular surfaces are wave surfaces.

It is shown that the matter of the molecules passes freely through the medium or vice versa. What does this imply?

That the singular surface has all the characteristics of a wave boundary.

If the medium is stationary and the molecules are moving with the earth, the grains within the surfaces do not partake of the mean motion of these surfaces, being continuously replaced by other grains by the action of propagation, by which the singular surfaces in their motion are continually absorbing the grains in front and leaving those behind without any mean effect on the motion of the grains. And thus there is perfect freedom of motion of the molecules or aggregate matter, although the grains which constitute the nuclei are changing at the rates expressed by 20 miles a second.

To be standing on a floor that is running away at a rate of 20 miles a second without being conscious of any motion, is our continual experience; but to realize that such is the case is, certainly, a tax on the imagination.

Such a motion has all the character of a wave in the medium; and that is what the singular surfaces, which we call matter, are - waves. We are all waves.

9. The molecules are individuals.

The singular surfaces which we call molecules are individuals, which although they may cohere, cannot pass through each other; and thus although the only mass, that of the medium, is changing every instant, at the extreme rates already mentioned, these singular surfaces or molecules preserve their individuality, the realization of which is a further tax on the imagination."

Reynolds' also talks about the existence of positive inequalities or places where there are excesses of aether grains (11, p. 39):

"The efforts of the positive inequalities are the reverse of the negative inequalities, tending to separate the positive centres, and cause the positive inequality to scatter through the medium, thus dissipating any effects throughout the medium. Then, since the space occupied by inequalities is almost indefinitely small compared to the space in normal piling, it appears, even if there are as many positive inequalities as there are negative inequalities, the positive will present no evidence, being scattered, while the negative inequalities, being brought together by gravitation are in evidence."

One might imagine dislocations with a net excess of aether grains to be antiparticles. Here Reynolds points to a possible explanation for the apparent absence of antimatter in our universe.

This concludes this portion of the paper on the background of Reynolds' SMU theory. I believe that the material thus far presented accounts for the theory's neglect. The remainder of this paper relates the theory to currently accepted physical theory and gives reasons for my position that Reynolds' SMU model should be rehabilitated.

Present day science pictures tiny, 'hard' particles zooming around in a lot of nothing (space) somehow mysteriously interacting via photons and nuclear, electric, magnetic, and assorted other forces. Reynolds' inversion, on the other hand, envisions dynamic systems of negative dislocations (holes) zooming around in a lot of structured something (a quasigaseous, quasicrystalline, dilatant medium) interacting with transverse vibrations (photons) and different types of stresses in the medium (gravitational, nuclear, electric, magnetic, etc. forces). This theory is compatible with both relativity and quantum theories. It is an aether which was not demolished by the Michelson-Morley (M-M) experimental results.

In writing this paper, I hesitated to use the term "aether". To use it is to invite derision or polite sympathy from most physicists, who will say that the M-M experiment disproved and that relativity theory did away with the need for an aether. It is true that M-M results disproved some aether theories; but the type of aether proposed by Reynolds, far from being disproven, actually permits visualization of the mechanism whereby the speed of light remains a constant.

As Einstein has shown, the observed speed of light is always a constant because the length of an object contracts in the direction of motion and its local time rate slows in perfect balance. Reynolds' theory enables me to show that the mechanism whereby this occurs is inherent in the very structure and dynamics of Reynolds' medium.

This medium is granular, composed of uniform, spherical grains much smaller than subatomic particles and filling the entire universe. In fact, it is the universe. In matter-free space, the grains are hexagonally arrayed and almost close-packed. Because they cannot normally exchange neighbors, they form a quasicrystalline matrix. The grains are in relative, vibratory, gas-like motion; but with a mean free path many orders of magnitude smaller than the diameter of the grains (unlike a gas). This jostling of the grains against one another produces a very high pressure in the medium. Because of the gearing of the grains and the pressure, the medium supports transverse disturbances (EM waves) whose local propagation rate depends on the local pressure and strains in the medium.

Reynolds says matter is strained regions of misalignment of the grains or "singular surfaces", "negative inequalities", or simply, "holes". Matter, then, moves by means of displacement; much as a bubble moves upward by an equal amount of liquid being displaced downward. For holes to move through the medium, aether grains must move in the opposite direction. With this as a background, I will now use Reynolds' SMU model to attempt an explanation of the

theoretical results of special relativity. Here is a demonstration of my intuitive, analogical reasoning.

Picture a void, hole, or "singular surface" having two plane, parallel faces. For this hole to move in a direction perpendicular to the faces, aether grains must leave the forward face and travel to the rear face of the hole. Since the distance the grains must travel is larger than the normal grain spacing and since they travel at a limited velocity, the grains spend a certain amount of time in transit across the singular surface. Their mean free path increases substantially from that of the medium in normal packing. While in transit, the grains do not vibrate against other grains and their energy is momentarily unavailable to the rest of the medium.

As the hole moves faster, the number of grains in transit across it increases. This causes a local decrease in aether pressure. Also, as more grains leave the front face, it experiences a loss of pressure and produces an aether strain tending to cause the front face to approach the rear face. This results in a contraction of the hole (matter) in the direction of motion. Here is a mechanical explanation for the Lorentz-Fitzgerald contraction.

The vibration rate of the grains determines the pressure in the medium and this determines the rate at which light waves are propagated. Thus, as the speed of matter moving through the medium approaches the speed of light, the local aether pressure decreases. This decrease in pressure means a decrease in the local passage of time, it causes clocks to slow. Here is a mechanical explanation for time expansion.

As the speed of the hole approaches the mean velocity of the grains (which, in part, determines the speed of light) the local aether pressure approaches a value close to zero. Reynolds identifies gravitational and inertial effects with the inward, radially directed aether strain on a volume containing holes (matter) and the dilatation this strain produces. As the local aether pressure drops to a low value, the aether strain rises to a high value. This aether strain increase is synonymous with a mass increase. Here is a mechanical explanation for the increase of mass with velocity.

The above explanations are, admittedly, intuitive, nonmathematical, and analogical. But there must surely be some merit in a model which allows visualizing the way in which motion causes distortion of the space-time continuum. This is the beauty of Reynolds' SMU theory. It makes possible the visualization of phenomena, which formerly were grasped mainly by mathematical relationships. "Don't try to picture it; the equation is the whole reality", is a point of view which promulgates mystery in physics. Reynolds' theory can demystify physics and bring to bear, once again, that powerful human faculty of visualization to the subject. In this simple, elegant model, the pressure of the aether, the interlocking structure of the aether grains, and dilatation attending strains in the medium are first order effects. All of the known physical phenomena are higher order effects deriving from these first order effects. The grains are the only invariant, three-dimensional "objects" in the universe not subject to relativistic effects.

Reynolds' aether theory also works with quantum theory and the theory of elementary particles as I hope to show in the following paragraphs.

As quoted above, Reynolds explains charge by means of a complex inequality, an aether grain deficiency-excess pair. His explanation can be adapted to modern physics as follows. To be an electron, a paired dislocation would have to have a net excess of deficiencies for normal mass. An antiparticle (positron) would have negative mass represented by an excess of aether grains. The annihilation of the opposing two dislocations would involve a disruptive shift of excesses and deficiencies to produce normal piling and an accompanying transverse disturbance in the medium (a photon). Conversely, a high-energy transverse wave traveling close to a heavy nucleus (region of high strain) can cause a disruption in normal piling and create an electron-positron pair. Here is an explanation for the creation and annihilation of matter.

Normal matter with a deficiency of aether grains is gravitative matter. Reynolds says that there is no evidence of matter with a net excess of aether grains because these particles tend to repel each other and to disperse instead of coalescing. Presumably, matter with a net excess of aether grains is antimatter. Here is an explanation for the absence of antimatter in our universe.

The wave-particle duality of EM radiation is less of a paradox with Reynolds' SMU theory because a photon is a transverse wave in a particulate medium. The medium is discontinuous. It could be called a "discontinuum" or a "quantinuum".

Reynolds' SMU is a structured medium which provides an explanation for the existence of long-range order in the universe. Metaphysically, it provides a matrix within which all interactions take place. Interconnectedness is a natural consequence of the SMU. Somehow, Reynolds' universe seems a cozier place than a universe with an unstructured emptiness.

The existence of time asymmetry; of time's arrow can be explained by the existence of the normal wave traveling at 2.4 times the speed of light. It is a precursor phenomenon which defines the direction of interactions.

In the above paragraphs, I have given intuitive explanations based on Reynolds' SMU theory. His quasigaseous, quasicrystalline, dilatant medium can also provide mechanical, kinetic, structural, and thermodynamic explanations for:

1. the different ranges of the physical forces,
2. nonradiating orbits of electrons around the nucleus,
3. the strong and weak nuclear forces,
4. the numerical relationships between physical constants, etc.

In his Magnum Opus, Reynolds starts from fundamental axioms and produces many detailed analytical, mathematical derivations. I have not included any of his analytical derivations here.

However, I do feel that the intuitive, descriptive material above should be augmented with some of the quantitative results of the theory. On the basis of empirical data circa 1900, Reynolds computed values for the parameters of his model of the aether. These values may lead to conclusions which disagree with our current knowledge of the universe. It must be stressed that such disagreement might be eliminated by choice of a different set of parameter values without invalidating the SMU model, itself. Reynolds' computed values (in C.G.S. units) are (1, p. 237):

Grain Diameter = 5.534 x 10 exp(-18)
Mean Relative Velocities of the Grains = 6.777 x 10
Mean Path of the Grains = 8.612 x 10 exp(-28) Mean
Density of the Medium = 10 exp(4)
Mean Pressure of the Medium = 1.172 x 10 exp(14)
Coefficient of Transverse Elasticity = 9.03 x 10 exp(24)
Rate of the Transverse (EM Shear) Wave = 3.004 x 10 exp(10)
Rate of the Normal (Compression) Wave = 7.161 x 10 exp(10)
Time to Cut Transverse Wave Energy from 1 to 1/e2 = 1.785 x 10 exp(15)
Time to Reduce Normal Wave Energy from 1 to 1/e2 = 3.923 x 10 exp(-6).

One might wonder how the mean grain velocity of 68 centimeters per second translates to the velocity of light. This works because the transmission of momentum across the diameter of the grain itself is assumed to be instantaneous. Thus the only distance a disturbance need travel from grain to grain is the mean path of 8.6 X 10 exp (-28) centimeters. Bumping across about 10 exp(18) of these distances in a centimeter translates to a transverse velocity of 3 X 10 exp(10) centimeters per second.

Reynolds' grain diameter is about 5 orders of magnitude smaller than current values of a nucleus (about 10 exp(-13) centimeters). Thus, one might say that here is a subquantic medium, dislocations in which could correspond to the elementary particles.

On the basis of the above list of parameter values, I calculated some figures which agree reasonably well with known physical measures. The diameter for the smallest sphere of grains which could detach itself from the rest of the grains in the medium and rotate independently, which I call the 'mean free sphere', I calculated to be 3.5 X 10 exp(-8) centimeters. This is close to the measured value for atomic diameters. The mass of a minimal shell around the mean free sphere came to 4.3 X 10 exp(-28) grams; again, not too far from the measured electron mass of 9.1 X 10 exp(-28) grams. These rough numerical agreements are not offered as proof of the theory. However, they are suggestive enough that others might be motivated to examine Reynolds' aether more closely.

High-energy experimental physics has resulted in the production of an ever-increasing catalog of more than 100 "elementary" particles. This diversity cries for a unifying foundation, for Reynolds' SMU theory. Some theoretical physicists are moving in this direction. Bohm starts his inaugural lecture delivered at Birkbeck College, February 1963 as follows (14, p. 279):

> "In the past half century or so, there has been a series of far- reaching changes in the basic concepts of physics, i.e., those concerned with space, time, movement and the nature of matter. These changes have not led to a stable set of concepts in recent times. Rather, it seems that they have given rise to a new set of problems, centering on the effort to combine relativity, quantum theory, and the theory of elementary particles into a single self- consistent whole. The failure of persistent efforts to resolve these problems has gradually led to a growing conviction among physicists, that what is probably needed is a set of changes that may well be even more revolutionary than those which have already occurred over the past fifty years."

Bohm goes on to discusses the analogy of his new approach to that of dislocations in a crystalline medium (14, pp. 297-298):

> "A dislocation is a break or discontinuity in the crystal structure. "
>
> "Each dislocation, besides being constituted of a discontinuity, ... which is localized in a particular segment of the general structure, also produces a distortion of the surrounding lattice, which actually spreads through the whole structure, falling off in intensity as the distance from the discontinuity ...
> increases. If we compare the particle with the dislocation, we can compare the field produced by the particle with the general distortion of the structure of the whole crystal. It should be noted that in this kind of theory, we do not regard field and particle as separately existing entities, brought together in interaction, as is done in current field theories of physics. Rather, field and dislocation are simply two sides of a total structure, so that one implies the other in a logically necessary way. [Indeed using the standard methods of homology theory in topology, one can show that the typical field equations, such as those of Maxwell, can be visualized as relating the distortion of a general background structure of space to the distribution of dislocations inside the distorted region. In such a treatment charge is interpreted as a kind of dislocation.]."
>
> "This theory must, of course, be extended to include the three dimensions of space as well as time. In addition, the notion of a perfectly regular structure can be replaced along lines that we have already discussed, by that of a more irregular structure that is fairly homogeneous. In this case, one finds that the structure can have a number of different kinds of dislocations. <u>The number seems large enough to accommodate the known types of "elementary particles".</u> (underlining by B.R.)..."
>
> "As in crystals, one finds that each pattern has a peculiar relationship to its mirror image pattern, such that two can combine to annihilate each other, producing no dislocation at all. In this way, the particle-antiparticle combinations of modern

> physics are explained, as well as the peculiar fact that the antiparticle obeys equations that are obtained from those of the corresponding particle by a reflection operation. ..."
>
> "At present, work is proceeding on the problem of trying to relate the known particles to dislocations in the space-time structure. It is too early to state the results. However, the problem is to try to see which dislocations correspond to which particles. ..."

Certainly the crystalline subquantic medium envisioned by Bohm above is surprisingly similar to the quasicrystalline medium of Reynolds' SMU.

There are other modern scientists who have similar visions of a higher unity. Dirac has demonstrated analytically that the existence of an aether is not ruled out by quantum theory (15). de Broglie, and Vigier (16, p. 131) also postulate the existence of a subquantic medium.

Both Bohm's and Reynolds' aether theories envision a structured matrix with a graininess much finer than subatomic particles. In Bohm's medium, elementary particles are analogous to dislocations in a crystalline matrix. He says that there are enough different types of dislocations in such a cohomological crystal to account for the number of known elementary particles.

The stress fields in the crystal are analogous to the various physical forces exerted by the particle. The particle cannot exist without the stress fields, nor the stress fields without the particle. Hiley (17), continuing the work on cohomology theory, refers to Bohm's work (14) and echoes much of what I quoted above. Hiley (17, p. 188) also references Frank (18, pp. 131-134) who has shown in a theoretical analysis that a Burgers screw dislocation moving through a crystal experiences relativistic effects, which can be determined by substituting the transverse velocity of sound in the crystal for the speed of light. The Zeitgeist is moving in the direction of Reynolds.

Given the obscurity into which Reynolds' SMU theory fell, it is not surprising that Bohm and his modern-day friends of the aether seem not to have known about Reynolds. At least I found no reference to Reynolds' work in any of their papers. Would it not be tragic for them to be reinventing Reynolds' SMU wheel?

The first half of the twentieth century was rich with theoretical advances in physics. Since that time, technology has developed practical applications of these new theories. It seems that the new lands charted by these theories are well explored and cultivated. There remain few new vistas. The time has come for a new perspective; for a revitalized vision of the physical world. Reynolds' quasicrystalline subquantic medium, with its potential to unite general relativity, quantum theory and elementary particle theory, is a paradigm upon which a new physics for the third millennium might be built.

Osborne Reynolds' Submechanics of the Universe: A Bridge between Classical and Modern Physics

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